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Verbal actions of physiotherapists to enhance motor learning in children with DCD

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Abstract

In this study, the motor teaching principles taxonomy (MTPT) was developed to investigate which teaching principles physiotherapists use to treat children with developmental coordination disorder during Neuromotor Task Training (NTT). In NTT, special attention is paid to the best ways to instruct and provide feedback. Based on motor learning theory and video observations of NTT treatments, teaching principles aimed at improving motor learning were categorised into three categories: giving instruction, providing or asking feedback, and sharing knowledge. The MTPT's reliability and validity were satisfactory. Therapists gave instructions very frequently. In addition, the principle frequency showed hardly any correlation with the children's initial motor performance level, indicating that the principles used are not related to the child's entry level.

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1. Introduction

The essential feature of *developmental coordination disorder* (DCD) is a marked impairment in the development of motor coordination (Diagnostic and statistical manual of mental disorders 4th edition, American Psychiatric Association, 1994). DCD can be apparent in a variety of skills that require actions of the motor system. The level of motor coordination is below that expected given the child's chronological age and intelligence, in the absence of any known neurological disorder, and leads to problems in daily life activities, which include playing and academic performance. There is a great need for treating this disorder because most children do not outgrow DCD (Cantell, Smyth, & Ahonen, 1994; Christiansen, 2000; Geuze & Borger, 1993; Hellgren, Jilbergt, Gillberg, & Enerskog, 1993; Losse et al., 1991), and it can lead to several long-term consequences such as an increase in medical events, less interest in sports and social problems (Henderson & Hall, 1982).

Several approaches are used to treat children with DCD, as no single approach works for everyone due to the heterogeneous symptoms of DCD (Wallen & Walker, 1995). For many years now, the main treatment objectives have been to remediate underlying processing deficits and facilitate neuro-maturational development. The effectiveness of these bottom-up approaches, like Sensory Integration Therapy, perceptual-motor training or kinaesthetic training, has been studied. Mandich, Polatajko, Macnab, and Miller (2001) concluded in a review study that no bottom-up approach was reliably better than no treatment at all, and suggested that the positive effects found in evaluation studies could be explained by simple maturational effects.

As children with DCD by definition have problems with performance in daily activities, more functional treatment approaches have been emphasised (Mandich et al., 2001). It is obvious that children with DCD fail to acquire skills that many children learn informally and perform without close attention (Henderson & Henderson, 2002).

Therefore, in the more recently developed top-down approaches, the main objectives of treatment are formal tuition and skill acquisition. Therapists become teachers who guide the child in the process of learning motor skills. Evidence for the effectiveness of these approaches is just now becoming available (Polatajko, Mandich, Miller, & Macnab, 2001; Schoemaker, Niemeijer, Reynders, & Smits-Engelsman, in press; Smits-Engelsman, Niemeijer, & Van Galen, 2001).

An example of a top-down approach is the recently developed Neuromotor Task Training (NTT). Schoemaker et al. (in press) showed that treatment according to NTT has positive effects on handwriting and on fine and gross motor skills that were measured with the M-ABC tasks. NTT incorporates several principles derived from motor control and motor learning research (Schmidt & Lee, 1999). It is a child-centred intervention focused on treating functional motor skills. While it is a mainly task-oriented method, motor control processes are analysed and trained during practice. A great deal of attention is also given to motor teaching principles. Research has shown that applying the most effective teaching principles can enhance motor learning in general and transfer in particular. The influence of the

therapist may be especially significant in top-down approaches such as NTT, where the therapist must give the formal tuition. Therefore, while treatment approaches tend to only describe in detail the motor control theories on which an approach is based, NTT also instructs therapists about the best ways to instruct or to provide feedback.

The primary aim of this study was to develop a motor teaching principles taxonomy (MTPT) in order to investigate what teaching principles therapists trained in NTT actually used in daily practice. Even though the participating therapists all provided treatments based upon NTT, they were likely to have different styles for tutoring children. In order to gain insight into whether therapists applied the teaching principles they had learned, treatment sessions were recorded on videotape. With the MTPT, the therapeutic actions (i.e., those aimed at improving motor learning) could be classified during such observations. In this paper we describe the developmental process of this taxonomy as well as the reliability and preliminary validity of the MTPT.

2. Method

2.1. Intervention

The Neuromotor Task Training treatment programme is taught in today's curriculum for paediatric therapists in the Netherlands. It is mainly task-specific or skill-based, which means its focus lies on direct teaching of the tasks to be learned. The choice of tasks depends on the individual needs of the child as well as on the expectations, capabilities and motivation of the child and the parents. By increasing the level of difficulty within the same functional task, this form of training is expected to have a higher transfer to daily activities. Within the NTT approach, physiotherapists start by assessing the strengths and weaknesses of a child's functional performance. The entrance level of training a skill is determined by loading various aspects of the task performance. In goal directed movements, this could be speed or accuracy in relation to distance and target size. Paediatric physiotherapists design the functional exercise in such a way that they can analyse which motor control processes are deficient. For instance, if providing a secure and supportive surrounding improves ball catching, task training will aim at more psychological processes. If, however, a child can catch the ball only when standing still and is warned beforehand, ball catching in complex and attentionally demanding situations will be trained. If the child has not yet developed a throwing pattern, the opportunity of merely throwing a variety (size, weight, material) of objects will be given. A demand on parameterisation will gradually be introduced later, by propelling the object over various distances or by aiming the objects at targets of different sizes. Through NTT, functional skills are trained in such a way that they tap the specific motor control processes that are thought to be involved.

The therapists received additional training in applying effective motor learning principles, on how to give instructions and provide feedback during their treatment

of children. In their textbook on motor control and learning, Schmidt and Lee (1999) discuss 'prepractice conditions' in which motor learning can be enhanced when the child is not directly engaged in practice. These conditions involve learning motivation (goal setting) and provision of verbal information. The NTT program pays special attention to how therapists teach a child a skill. Future NTT therapists are taught to choose between different learning options, such as implicit, guided discovery or explicit learning. The process of learning complex skills shows multiple phases or stages of explicit learning: the cognitive phase, the associative phase and the autonomous phase (Fitts, 1964). It prioritises giving the child some sort of 'idea' or image of the task to be learned, be it through verbal instructions, use of videotapes and/or demonstrations. According to Schmidt and Lee (1999), clear instructions about what task to perform, how to perform it, and what to attempt to achieve as a score, are critical for motor learning. Less effective is the instruction 'go'. Therapists should therefore give instructions (clues) that provide useful and important information about the movement itself, such as the initial positions relative to the surroundings. Instructions can also stress ways to recognise one's own errors. After performing a motor task, providing feedback about what was done may be essential for skill learning. Therapists can talk about the outcome of movement (results) or about the nature of the movement pattern (performance). Providing adequate feedback on performance may enhance motor learning, especially in children with motor problems. Furthermore, in NTT both the motivational and informative functions of feedback are emphasised.

The paediatric physiotherapists willing to participate in a research study on the effectiveness of NTT learned NTT during their three-year training as PPT and two extra meetings especially for purposes of this research. During the first meeting, an update was given on NTT. Then therapists recorded a treatment session on videotape while treating the child according to NTT principles. At the second meeting the tapes were brought in, and were used to develop a critical approach to the therapists' habits and to stress the NTT principles in their treatments. Tapes were randomly started and stopped after approximately 2 min. All kinds of questions were asked, such as 'why do they practice these skills?', 'what could be the reason these skills were trained?', 'what does the child think after the remarks the therapist made?', 'what would you say to this child?'. The group size of no more than 10 therapists allowed for exploration of such questions and all possible answers.

2.2. The development of a motor teaching principles taxonomy

A motor teaching principles taxonomy was developed to classify overt and directly observable therapeutic actions, that is, actions by therapists aimed at enhancing motor learning. MTPT serves as an instrument to analyse video recordings of the treatment of children with DCD by physiotherapists trained in NTT. It is more than just a description of actions by therapists, because it combines theory and practice. The taxonomy is the final result of a cyclical process that incorporated knowledge from motor learning research as was emphasised in NTT (see section on intervention) and the observation of therapeutic actions on videotapes.

2.2.1. *The developmental procedure of the MTPT*

The development of the taxonomy was a two-sided procedure: it was necessary to adopt a theoretical framework in order to subsequently observe in practice the situation in which the taxonomy would be used. Theory and practice overlapped as long as was necessary to develop a theory-driven instrument. Recent knowledge on motor learning, such as how to give instructions or feedback to children, were the building blocks for the teaching principles formulated in NTT. This knowledge guided the researchers in developing the taxonomy.

To begin with, Schmidt and Lee's definition of motor learning was adopted ('motor learning is a set of internal processes associated with practice or experience leading to relatively permanent changes in the capability of motor skill', 1999, p. 264). To find out what therapist behaviour could be seen as representative for this motor learning, the researchers watched video recordings, made by the therapists who brought them in for their NTT training. The researchers made an inventory of all deliberate actions by the therapists that seemed overt to people watching the video recordings, and which were assumed to aim at realising relatively permanent changes in motor performance. Thus talking about the weather or doing math were not considered to improve motor learning, although small talk can provide a nice working atmosphere that might help a child's motivation to learn. As a result, mainly therapeutic verbal actions (purposeful and deliberate verbalisations) were registered, such as 'make a little basket of your hands when catching the ball', 'try to touch my hand with your head', 'try not to make a loud noise when you land on the floor', or 'very good' and 'okay'. Manipulations of body parts and physical demonstrations could also be observed directly and were registered. The result of this developmental preparation phase was a long list of observed therapeutic actions.

In the following phases, all observed and listed actions were clustered into one teaching principle if they were similar. For example, 'try to jump twice' or 'throw the ball' were considered as one teaching principle that was named 'giving commands'. This clustering process was guided by the researchers' knowledge of motor learning. The teaching principles, clusters of therapeutic verbal actions, were labelled by active voice without theoretical terms. This made the observations easier, because the principles refer directly to what happens. After this clustering process, the distinctions in NTT between 'giving instruction' and 'providing feedback' were used to categorise the principles. At the end of the procedure we can distinguish three levels in the MTPT. At the highest level, we find classes of therapeutic behaviour close to the definition, hence to the 'theory' of Schmidt and Lee (1999). At the second level we find smaller parts of these behavioural patterns – the motor teaching principles. And on the third level we find the concrete verbal actions aimed at enhancing motor learning in children during a treatment session.

2.2.2. *Analyses of the psychometric quality of MTPT*

The psychometric requirements of a classification scheme include completeness, mutual exclusiveness, reliability and validity (Reynders, 1992).

- The completeness requirement refers to whether all possible verbal actions aimed at enhancing motor learning observed by the researchers were covered by a teaching principle. To this end, six other video recordings brought in by therapists for their final instruction in NTT were observed and analysed with the Noldus software program *Observer 4.1*. Whenever the principles did not cover all actions, new principles would be created.
- Mutual exclusiveness was reached when a therapeutic action could be covered by only one teaching principle and could thus be classified in only one category of the taxonomy. An indication for this requirement was obtained by reliability measures.
- Reliability was measured through intrarater and interrater reliability measures. The agreement was corrected for chance using Cohen's kappa. A value above 0.60 is regarded as satisfactory (Van de Sande, 1999). Intrarater reliability (consistency of observations) was assessed by comparing two observations with an interval of at least one week, and interrater reliability (objectivity of observations) was assessed by comparing observations of the tape by the research assistant and the first author of this paper.
- The MTPT is face-valid because the taxonomy does not predict a construct but describes the actions directly (Nunnally, 1967). The validity of the MTPT will be good if no extension of the teaching principles or categories is required for the observation of other video recordings of NTT treatment sessions (see completeness). It is also important that the interpretations of the data gathered with the MTPT be valid. The primary aim of the MTPT was to investigate what teaching principles therapists trained in NTT actually use to enhance motor learning in children with DCD. In order to report valid frequencies for each principle, the researchers decided that whenever therapists repeated their action because the child did not react, this action was included in the analyses only once. The principles used by therapists could however be different due to differences between therapists or children. This could harm the validity of the interpretation of the frequency with which teaching principles are used. We therefore examined whether the MTPT frequencies observed during 30 min NTT sessions were associated with therapists' age or the motor performance tests scores of the children with DCD. The existence of associations would indicate that the observed frequencies would have to be interpreted with care, because other therapists or the treatment of children with other motor performance levels would lead to different results.

2.3. *Participating therapists*

The professionals participating in this study were registered in the Netherlands as paediatric physiotherapists. Instruction in Neuromotor Task Training was given to the therapists at the start of this study. Thirteen female therapists, aged 37–53, treated the children in the study.

2.4. *Selection of participating children*

Twenty-three children were referred to physiotherapy by their general practitioner (GP) because of motor coordination problems in school and/or at home. This indi-

cates that their poor motor coordination interfered with activities of daily living (Developmental Coordination Disorder, criterion B, DSM-IV, 1994). The paediatric physiotherapist examined each referred child with the General Psychomotor Assessment Protocol for DCD (Smits-Engelsman, Van Galen, & Schoemaker, 1997), in order to exclude obvious neurological disorders or other medical conditions that could explain the motor difficulties (criterion C, DSM-IV). This protocol included assessing the child with the M-ABC to identify whether performance was below the 15th percentile given his/her age (to check for criterion A, DSM IV). A child was included in the study if both the GP and the physiotherapist agreed that he/she needed individual physiotherapeutic intervention, and if all criteria for developmental coordination disorder were met. Additional requirements for inclusion were attendance of a Dutch regular elementary school, implying an IQ-score in the normal range (criterion D), no history of physiotherapy, and parents' informed consent. Eighteen boys and five girls with ages ranging from 5 to 10 were included. The mean age was 7 years 6 months (SD 1.1). The Medical Ethics Committee of Groningen University Hospital approved this study.

2.5. Protocol for extra video recordings

As a video camera intrudes in the situation created by the therapist and child, only one treatment session was recorded on video. This was not done until the child had had six sessions and thus had become acquainted with the therapist, the room and the material. By this time, too, the therapist had set goals for the intervention. The therapists did not know what purpose the video recordings were to serve: they only knew that the researchers wanted to know more about what was actually practised during the sessions because the treatment was like a black box to them. The recordings showed therapists' verbal and overt actions during one 30 min session.

2.6. Tests of motor competence

Although NTT is a task-oriented method, therapists tap the motor control processes that are assumed to be deficient while training functional skills. Only those skills are trained that needed training, or that child (and parents) wanted to be trained. Two tests of motor competence were used. A child was able to show his/her motor competence on a wide array of tasks (20).

2.6.1. The Movement Assessment Battery for Children, M-ABC

The M-ABC (Henderson & Sugden, 1992) is marketed by the Psychological Corporation in London. The test, which was validated for the Dutch population by Smits-Engelsman (1998), provides an indication of a child's motor functioning in daily life. The M-ABC is a norm-referenced test consisting of four age-related batteries. Each battery consists of eight motor tasks; three items measure manual dexterity, two items measure ball skills and three measure static and dynamic equilibrium. A lower score represents a better performance. When a child is tested with the appropriate age-band and norms, a score at or below the 15th percentile

means poor performance in comparison with his/her peers. In this study, the M-ABC was used by the therapists as an identification instrument for children with DCD, and as a research instrument by the researchers. This test is most often used to classify DCD and to measure effectiveness of treatment (Geuze, Jongmans, Schoemaker, & Smits-Engelsman, 2001). The standardised scores make comparisons within the broadest age range possible. The test is product-oriented as it measures motor competence in terms of speed and duration or the amount of successful attempts.

2.6.2. The Test of Gross Motor Development-second edition, TGMD-2

The TGMD-2 (Ulrich, 2000) is marketed by Pro-Ed, Texas. This test is a criterion- and norm-referenced test designed for the assessment of children aged 3 through 10. The instrument assesses gross motor functioning in two abilities: locomotor (LM) and object control (OC). For each of 12 skills, performance criteria were formulated and the observation of these leads to a raw score. A higher score indicates a better quality of movement patterns. The TGMD-2 provides several scores: raw scores, percentiles, age-equivalents, standard scores per ability, and a composite gross motor quotient (GMQ). The standard scores have a mean of 10 and a standard deviation of 3. Both standard scores can be converted into the GMQ, with a mean of 100 and a standard deviation of 15. The TGMD-2 (2000) possesses a high degree of reliability and little test error. Interscorer and stability-over-time reliability coefficients varied between $r = 0.88$ and $r = 0.98$ for both the LM and OC subtests and for the GMQ (Ulrich, 2000). In this study, the test is used because it measures 12 gross motor skills that are usually acquired by children in pre-school and early elementary grades. The test was also used because it is concerned with how the skill was performed, or the quality of movement patterns responsible for the performance outcome, rather than the product (Burton & Rodgeron, 2001). In addition, the norm-referenced standard scores make comparisons within the broadest age range possible.

2.7. Testing procedure

The paediatric physiotherapists assessed the child for inclusion in this study. For objectivity reasons, a research assistant from the Institute of Human Movement Sciences also tested the children. Each child was tested individually at the therapists' practices. Various motor tasks were used to determine the children's current level of motor performance. Besides the M-ABC and the TGMD-2, which are used in this study, several grapho-motor tasks were administered. Depending on age, the total test battery took 90–120 min to complete. Younger children needed more time for each task and were given more time to rest in-between tasks to avoid worsening performance with fatigue. Even though the physiotherapist had already assessed the child with the M-ABC, the assessment was repeated. In this way, the obtained results were more likely to be true test scores, because huge learning effects on the M-ABC are reported for children with DCD (Leemrijse, Meijer, Vermeer, Lambregts, & Ader, 1999). The researchers administered the M-ABC first, so that the results could be compared with other studies using the M-ABC. Subsequently, the child sat at a

table to do the experimental grapho-motor tasks on a digitizer for at least 10 min. After approximately 1 h of testing, the TGMD-2 was randomised with other grapho-motor tasks in such a way that the child was kept motivated and performed optimally.

2.8. Data analyses of test scores and MTPT frequencies

To find out whether the motor teaching principles applied were associated with motor competence scores, correlations were calculated between MTPT frequencies, age of the therapists and scores on the tests administered by the researchers (M-ABC or TGMD-2). Spearman correlations were used because many principles were not normally distributed. For greater accuracy, the researcher analysed the correlations with scatterplots. In this study, many correlation coefficients were checked for significance. This might lead to capitalising on chance. However, because the small sample size would reduce the power, the significance level was set at 0.05.

3. Results

3.1. The motor teaching principles taxonomy

To answer the question of which motor teaching principles were used by therapists to improve motor learning, all their overt actions were clustered into 20 principles. Some of these principles were difficult to categorise in either ‘giving instruction’ or ‘providing feedback’. Some therapists, for instance, explained why a movement should be executed in a certain way without directly telling the child that he/she should do it. This same kind of information was also observed after terminal feedback was given. Therefore another category was created, called *sharing knowledge*, which was often observed before or during the execution of a (new) practice trial. Therapists did not always provide feedback, they also asked the child to give feedback. The motor teaching principles taxonomy (see Table 1) thus contained 20 motor teaching principles in three major categories: (a) giving instruction to the child, (b) sharing knowledge with the child as part of the learning process, and (c) providing feedback or asking the child to give feedback.

Table 2 shows that Cohen’s kappa for the intrarater or test–retest reliability was between 0.63 and 0.99, and for the interrater reliability between 0.60 and 0.77 for the three categories. For the separate principles all figures were 0.60 or higher, which is good (Van de Sande, 1999).

3.2. Results of observation of 23 tapes with the MTPT

Table 3 shows that *giving instruction* was observed on average 37 times per session, SD 10.2 with a 23–56 range. Within this category many commands were given, 3–34 times in one session. Clues on how to execute a movement were observed once to 20 times. *Sharing knowledge* in the learning process was observed on average 20.9

Table 1

The motor teaching principles taxonomy, three categories with principles covering verbal actions of physiotherapists aimed at enhancing motor learning

Giving instructions	<p>Giving information on what to do</p> <ul style="list-style-type: none"> • Give commands • Draw attention and demonstrate the movement • Give clues on how to execute a movement • Manually change the body in order to make a desired action possible
Sharing knowledge	<p>Talking about movement tasks and execution (before or during execution)</p> <ul style="list-style-type: none"> • Explain why it is better to execute a movement in a certain way • Revert to earlier trials • Tell what the child is doing • Provide rhythm or timing • Explain the difficulty of a task • Ask the child about the difficulty of a task • Ask the child if he/she understands the task • Ask the child if he/she thinks he/she can do the task (attainability) • Ask the child questions about the movement execution of a task
Providing or asking feedback	<p>Providing comments or asking for comments after the task is completed</p> <ul style="list-style-type: none"> • Tell the child what was done right during the execution • Tell the child what was done wrong during the execution • Tell about the results of performance neutrally • Tell about the positive results of movement • Tell about the negative results of movement • Ask the child's opinion about the movement execution • Ask the child's opinion about the results of the task

Table 2

Cohen's kappa measures of reliability for three categories of the MTPT

	Intrarater 1	Intrarater 2	Interrater 1–2
Giving instruction	0.69–0.79	0.69–0.70	0.64–0.68
Sharing knowledge	0.81–0.85	0.73–0.85	0.70–0.71
Providing or asking feedback	0.66–0.99	0.63–0.90	0.60–0.62

times, SD 10.5 and 5–41 range. In this category, questions about how to execute a movement were observed most frequently. About the same amount of verbal actions were categorised as *providing or asking feedback*, mean 23.5 (9.3) with a 9–43 range. The feedback the children received generally concerned remarks about the positive results of their movement execution, on average 7.6 times in one treatment session. In addition, all therapists relayed positive results of the executed movements, with a range of 2–18 times. On the level of categories, the scores were all normally distributed. At the level of teaching principles they were either not skewed or skewed positively. Table 3 presents the frequencies of the different motor teaching principles and categories used.

The observation of the 23 new video recordings that were made by the researchers after the final training in NTT did not reveal new actions. All observed verbal ther-

Table 3

Mean and range of number of times (frequency) that MTPT categories and principles were used, and correlation coefficients of MTPT frequencies with the children's motor test scores

	Mean (SD)	Range	Correlation with M-ABC	Correlation with TGMD-2
<i>Category: giving instruction</i>	37.2 (10.2)	23–56	0.11	–0.15
• Give commands	18.4 (7.8)	3–34	–0.05	–0.11
• Demonstrate	3.5 (3.7)	0–13	0.14	–0.15
• Give clues	12.7 (5.12)	1–20	–0.28	–0.27
• Manually change body parts	2.7 (4.7) ^a	0–20	0.18	0.10
<i>Category: sharing knowledge</i>	20.9 (19.8)	5–41	0.15	0.14
• Explain why	3.1 (3.2)	0–13	0.22	–0.22
• Revert to earlier trials	2.9 (2.9)	0–12	–0.11	0.16
• Tell what is being done	2.1 (2.3)	0–8	0.01	0.03
• Provide rhythm/timing	0.1 (0.3) ^a	0–1	0.13	–0.14
• Explain the difficulty	2.4 (2.6)	0–11	0.40 (0.06)	–0.25
• Ask about the difficulty	1.4 (1.9) ^a	0–17	–0.03	0.12
• Ask about understanding/comprehension	0.4 (0.7) ^a	0–2	0.32	–0.16
• Ask about attainability	3.0 (2.9) ^a	0–12	–0.21	0.05
• Ask about movement execution	5.6 (5.3)	0–18	0.09	0.28
<i>Category: providing or asking feedback</i>	23.5 (9.3)	9–43	–0.09	–0.19
• Tell what went well	2.6 (2.1)	0–9	–0.25	–0.18
• Tell what went wrong	2.2 (2.9) ^a	0–13	–0.12	–0.36 (0.09)
• Tell about result neutrally	3.3 (3.2)	0–12	0.23	–0.12
• Tell about positive result	7.6 (3.5)	2–18	0.06	–0.23
• Tell about negative result	1.6 (1.3)	0–5	0.002	–0.003
• Ask opinion performance	4.3 (4.3) ^a	0–15	–0.17	0.10
• Ask opinion result	2.4 (2.4)	0–10	–0.19	0.30
Total verbal actions	81.8 (21.8)	39–128	0.17	0.02

p-values are provided in brackets when *p* < 0.10.

^a Means not normally distributed.

apeutic actions fitted in the specially developed motor teaching principles taxonomy. Moreover, after observation of 23 videos, Cohen's kappa for the intrarater or test–retest reliability was between 0.76 and 0.79 for the *giving instruction* category, 0.80 and 0.88 for the *sharing knowledge* category, and between 0.74 and 0.85 for the *providing or asking feedback* category.

3.2.1. Does the use of teaching principles differ with a child's initial level of motor performance?

The level of motor performance differed for the 23 children. All children were identified as performing 'at risk/deviant' (below the 15th percentile) during the physiotherapist's assessment with the M-ABC. The researchers' assessment showed that six children were scoring within normal on the M-ABC. The children's mean total impairment score was 15.1 (SD 6.2), and their performance also varied on the

TGMD-2, with a mean score of 73.4 (SD 12.3). Four children scored within normal limits on this test.

In Table 3, correlation coefficients are given for the association between the frequency of principles and the children's test scores. These coefficients show that two teaching principles used by physiotherapists tended to be related to motor performance. Whenever a child performed more poorly on the TGMD-2, therapists were likely to provide more feedback on what went wrong ($r_s = -0.36$, $p = 0.09$). If a child's performance was worse on the M-ABC, therapists would share knowledge about the difficulty of the task ($r_s = 0.40$, $p = 0.06$). No significant correlation coefficients were found between frequencies of MTPT principles and the age of the therapists.

4. Discussion

In this study, a motor teaching principles taxonomy was developed to investigate which teaching principles aimed at enhancing motor learning in children with developmental coordination disorder were used by physiotherapists during Neuromotor Task Training. NTT differs from many approaches because it pays special attention to teaching principles derived from recent motor learning research. During their training in NTT, therapists learned about different ways to instruct motor skills and provide feedback. Although the taxonomy was developed with these two teaching principles in mind, an additional category had to be created because several actions were ambiguous, e.g., 'if you bend your knees, it's easier'. These actions, in which therapists talk about movement tasks and movement execution with the child, could be observed before a new instruction was given (as feedback on previous performances), or during the execution of a movement. Therefore, all principles covering these actions were categorised as *sharing knowledge*. As a result of the developmental process, the MTPT consisted of 20 teaching principles in three categories: *giving instruction*, *sharing knowledge*, and *providing or asking feedback*. This last category contained feedback that was provided immediately after the child had executed a movement. It is referred to in research literature as final/terminal feedback. One might argue that the principles categorised in *sharing knowledge* are also forms of feedback, but then, the child could observe the provision of a repeated instruction in the same way.

The MTPT was checked for several psychometric properties: completeness, mutual exclusiveness, reliability and validity. After it had been proved to be reliable, through Cohen's kappa measures for interrater and intrarater reliability, the researchers made several new video recordings of NTT treatment sessions. During observation of these videos with the MTPT, all therapeutic actions could be covered. The MTPT also works as a very complete taxonomy to classify verbal actions of therapists aimed at enhancing motor learning during NTT treatments of children with DCD. Because the MTPT allows the behaviour of therapists to be observed directly, and not by means of a psychological construct or through manipulation, it seems face-valid (Nunnally, 1967). However, the actions observed were clustered into

principles which may allow for observer interpretation, even though the naming of principles was done in verbs for a close relation with all possible verbal actions. Interrater and intrarater reliability measures on the frequencies of used principles and categories showed that they were obtained in an objective and reliable way. This last finding is very important because it provides evidence that the definition of each principle was clear enough to prevent individual observers from interpreting the actions as different principles. It also means that the principles and categories were mutually exclusive, and that the MTPT can be used to describe what teaching principles therapists trained in NTT actually use to enhance motor learning in children with DCD.

Observation through the MTPT revealed that therapists used *giving instructions* most frequently. This means that children with DCD were encouraged to practice a lot during treatment sessions. According to Schmidt and Lee (1999), practice is very important for motor learning and therefore the number of practice trials should be maximised. Therapists have to give an instruction before a child with DCD knows what to do. Fewer actions, however, were aimed at improving motor learning through *sharing knowledge* or *providing or asking feedback*. The frequency of most principles was normally distributed, indicating that a clear picture was obtained about what therapists do. Still, the principles showed great variations in minimum and maximum use. Consequently, even though the participating therapists all provided treatments based on NTT, they differed in their tutoring styles.

The range of the number of principles frequently started at zero, indicating that those principles were scarcely applied. Only the three most frequently used principles were observed in each recorded treatment session at least once, namely giving commands, giving clues, and telling positive results. Each therapist used these principles, as emphasised in NTT. In order to stimulate children to keep trying, therapists have to give instructions. A command like 'go' is an instruction with a general goal, and stimulates the child to practice. Such commands were however given more often than clues (clear instructions about how to perform a task). According to the research discussed by Schmidt and Lee (1999), giving clues seems to produce better performance. NTT also emphasises that children with DCD need to experience success. The therapists accomplished this by telling the positive results of movement execution at least twice.

In the videotapes observed, therapists used teaching principles differently. This might be due to differences in therapists, children or the interaction between both. The only differential information on this study's therapists was their age, but we found no association between it and the different frequencies of the use of MTPT principles. In addition, most of the MTPT principles were not associated with the child's M-ABC or TGMD-2 test scores, so the choice of principles seemed to be independent of the child's entrance level. However, two theoretically important, non-significant correlation coefficients were found. Therapists explained the difficulty of a task more frequently to children with lower performance on the M-ABC, a test that assesses motor competence in terms of speed and accuracy. They also communicated more often what went wrong in the movement patterns and executions to children who had exhibited inferior motor patterns on the TGMD-2. This is a remarkable

finding, because therapists were unaware of the scores obtained by the children on the M-ABC and TGMD-2. The finding makes clear that these two teaching principles were likely to be applied to a different extent, depending on the children's performance levels.

Further research is necessary to investigate whether the differences in teaching principles vary because of other child-related characteristics, such as behavioural ones, or to the interaction between characteristics of therapist and child. So far, the MTPT has been shown to be a reliable instrument that can be used by researchers and therapists interested in examining which teaching principles therapists actually use during NTT. It would be very interesting to investigate whether the MTPT is comprehensive enough to cover the teaching principles used in other top-down approaches, such as the cognitive orientation to daily occupational performance (CO-OP; Polatajko, Mandich, Missiuna, et al., 2001) or in treatments of children with diagnoses other than DCD.

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